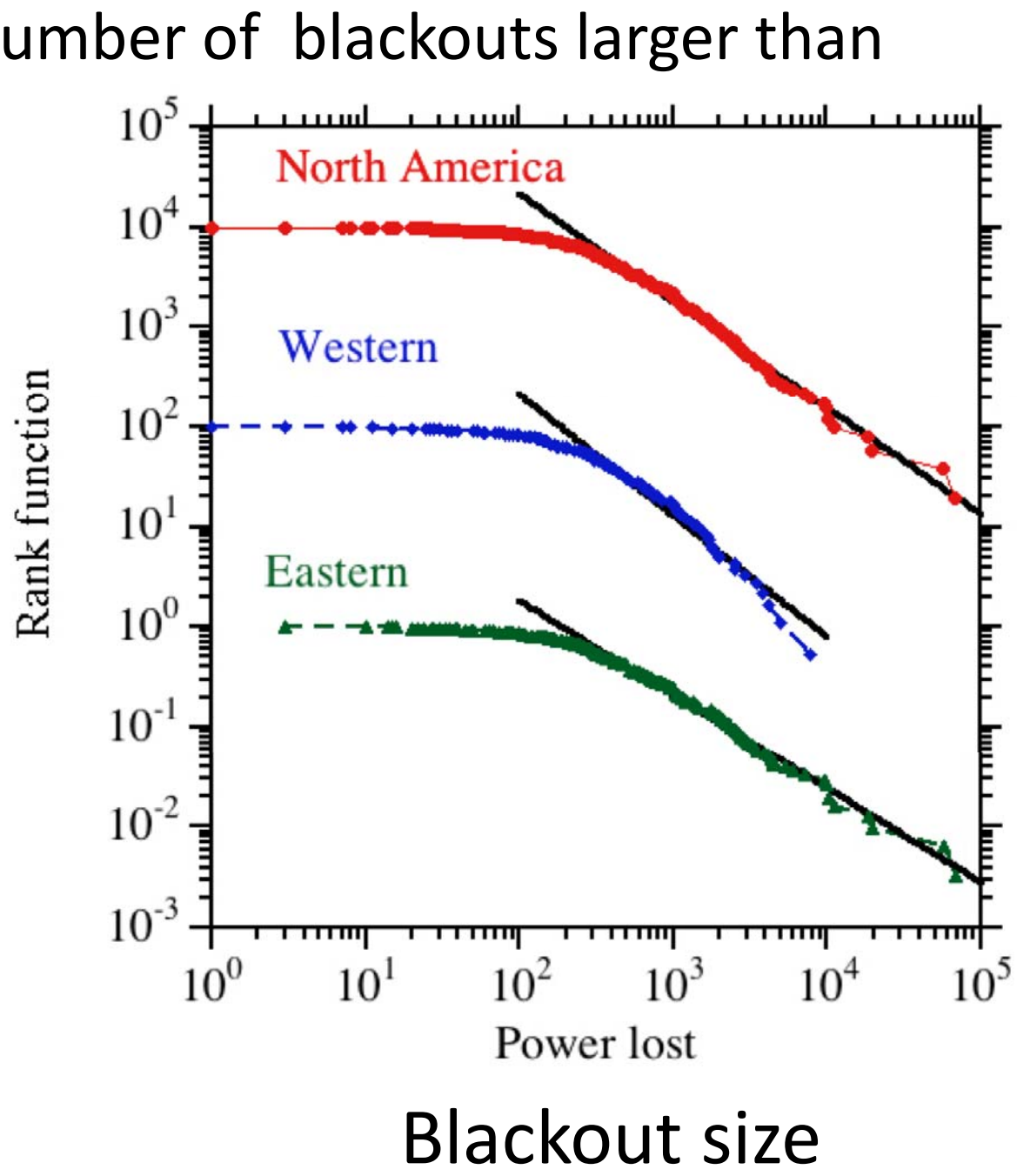
Extreme event research

Ram Adapa, EPRI
Ben Carreras, BACV Solutions
Ian Dobson, U. of Wisconsin
Rod Hardiman, Southern Company
Lorraine Hwang, CIEE
Murali Kumbale, Southern Company
Bernie Lesieutre, U. of Wisconsin
Yuri Makarov, PNNL
Mark Morgan, PNNL
David Newman, U. of Alaska
Nader Samaan, PNNL

California Energy Commission
TRP Colloquium 29 September 2009

NERC data shows heavy tails

- Large blackouts more likely than expected; due to cascading
- Large blackouts rare, but have high impact and significant risk



Challenges of large blackouts

- Complicated cascades of unusual and unexpected dependent events
- Combinatorial explosion of possibilities
- Many mechanisms for failure propagation

State of the art

- Detailed modeling and analysis of particular past blackouts
- Many rules and procedures that tend to reduce cascading
- Detailed modeling and analysis and mitigation for specific mechanisms

Extreme event project goals

- Establish CAISO grid models for state-of-the-art cascading failure simulations
- Quantify extreme event risk on CAISO grid models by improving, testing, and comparing multiple approaches.
- Identify network vulnerabilities, critical corridors, …
- Quantify reliability benefits of transmission grid upgrades.
- Define metrics of risk and ways to communicate the risk
- Evaluate state of art simulation and analysis methods and define a road map for feasible enhancements.

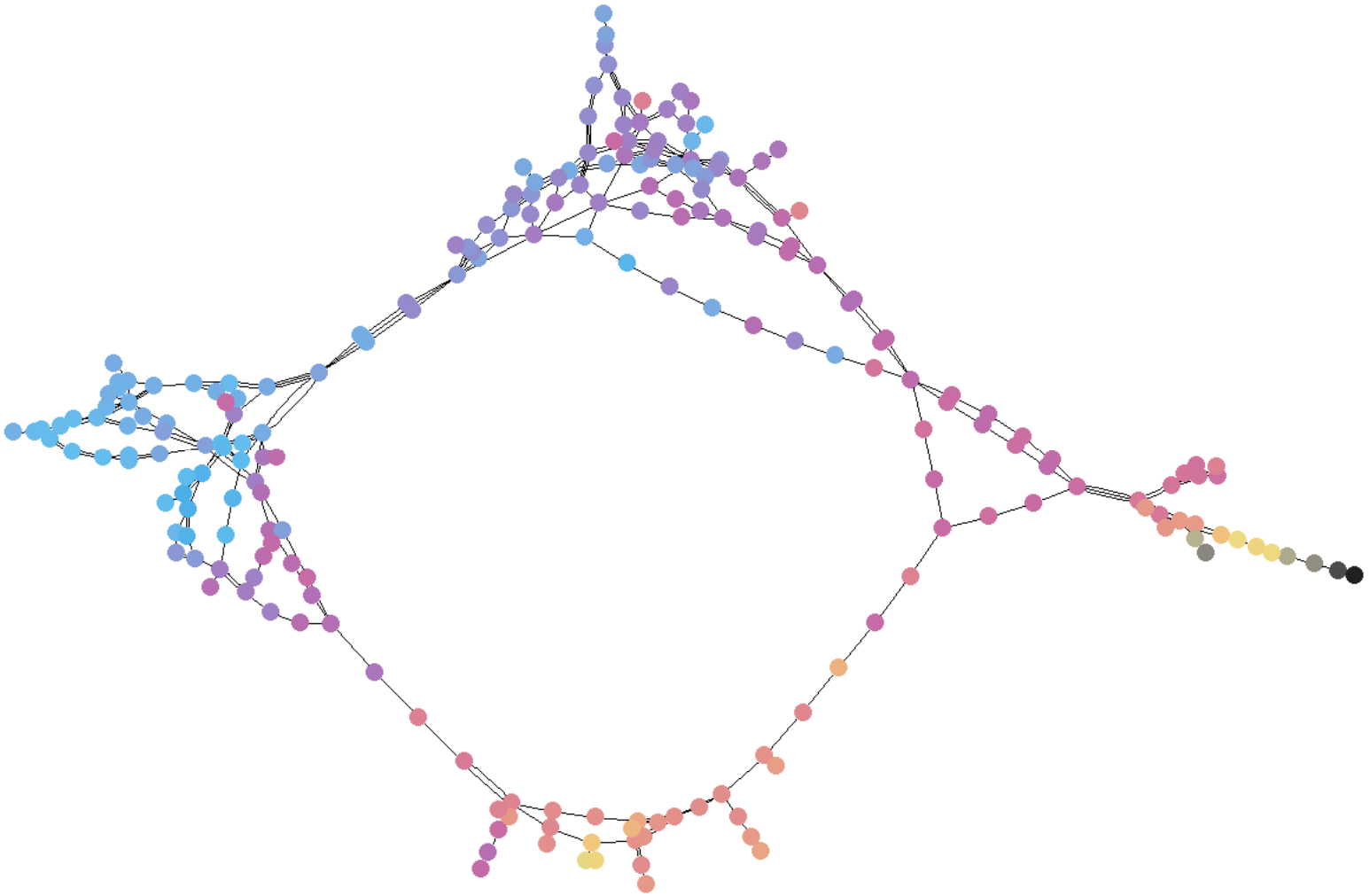
The two year, 1.1 M$ project started in March 2009

Different approaches

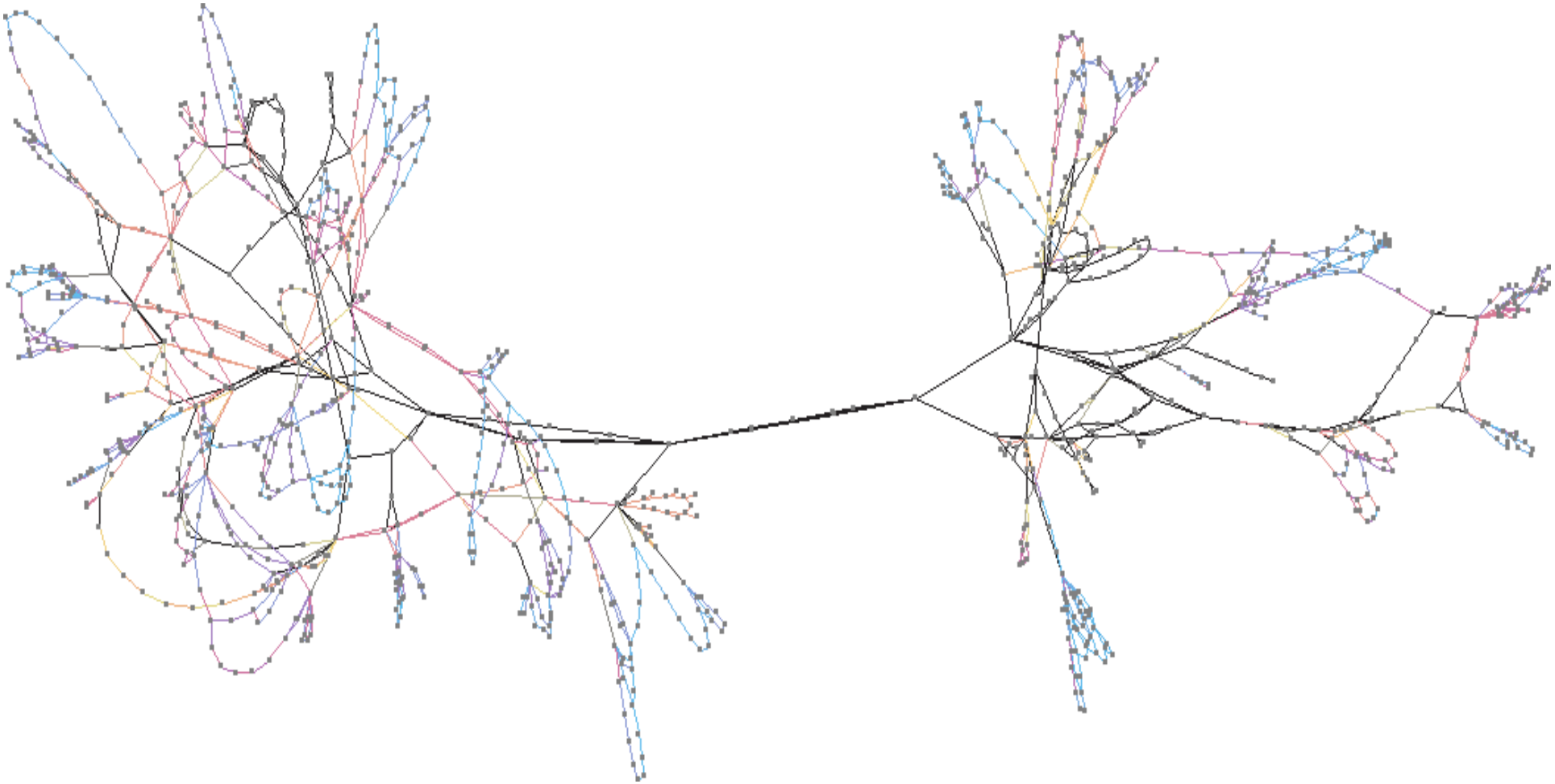
- NERC historical data
- TRELSS cascading simulation - industry
- OPA cascading simulation - research
- Graph-theoretic brittleness measures
- Branching probability models for cascading

Some models and initial results follow

WECC 225 bus



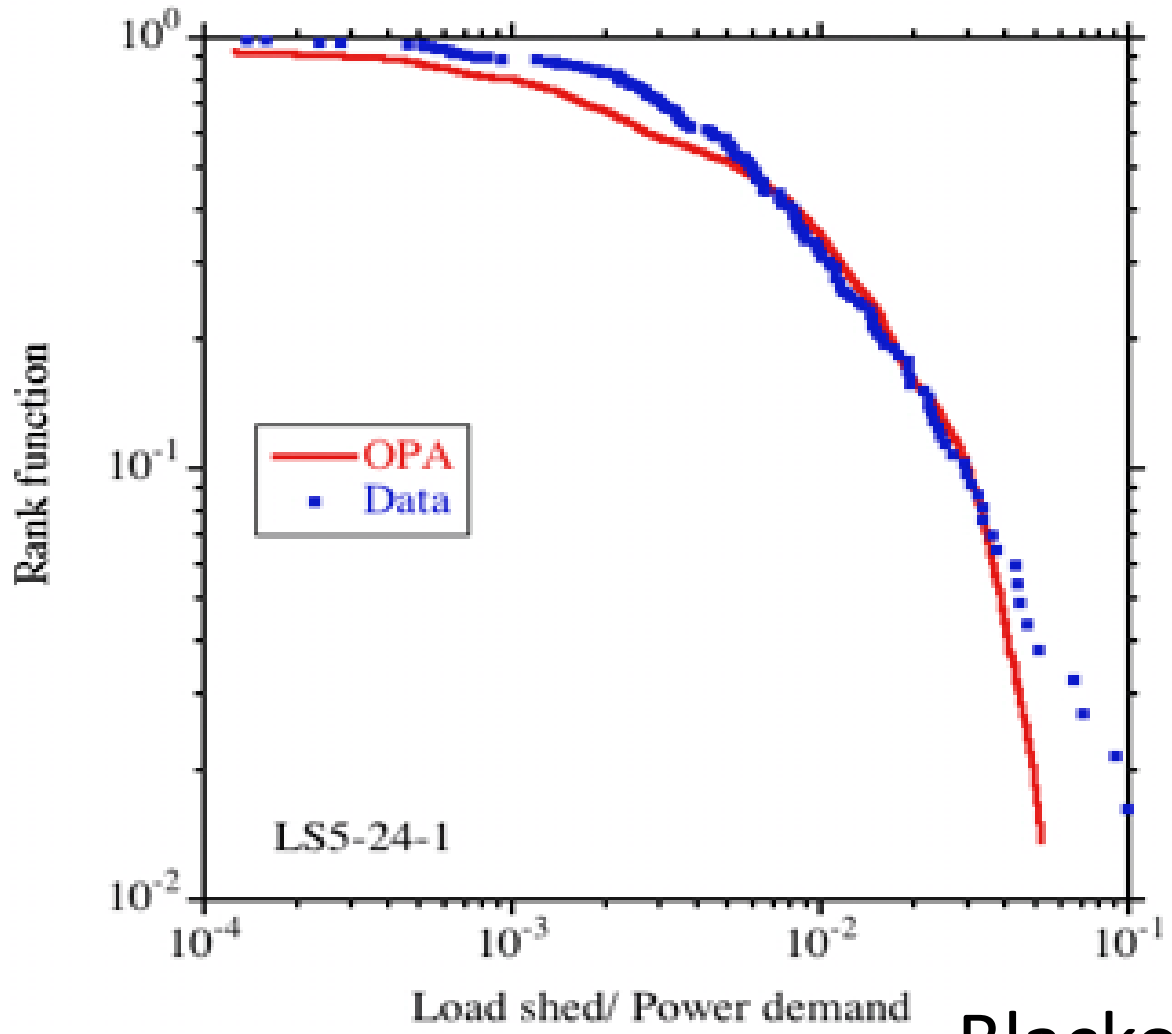
WECC CA-centric 1081 bus



Thanks to Irina Green, CAISO

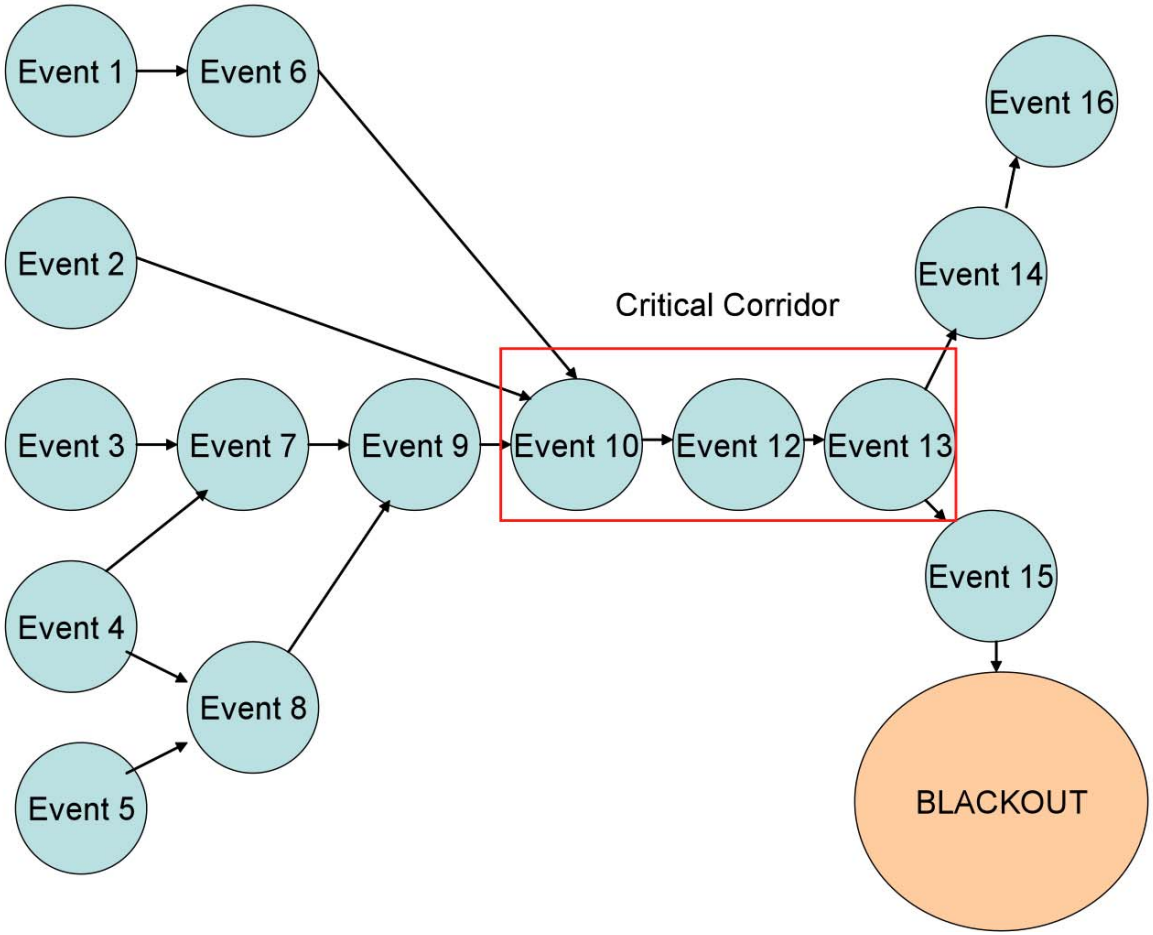
Can the simulations match real data?
OPA on WECC 225 and the NERC data

Number of blackouts larger than



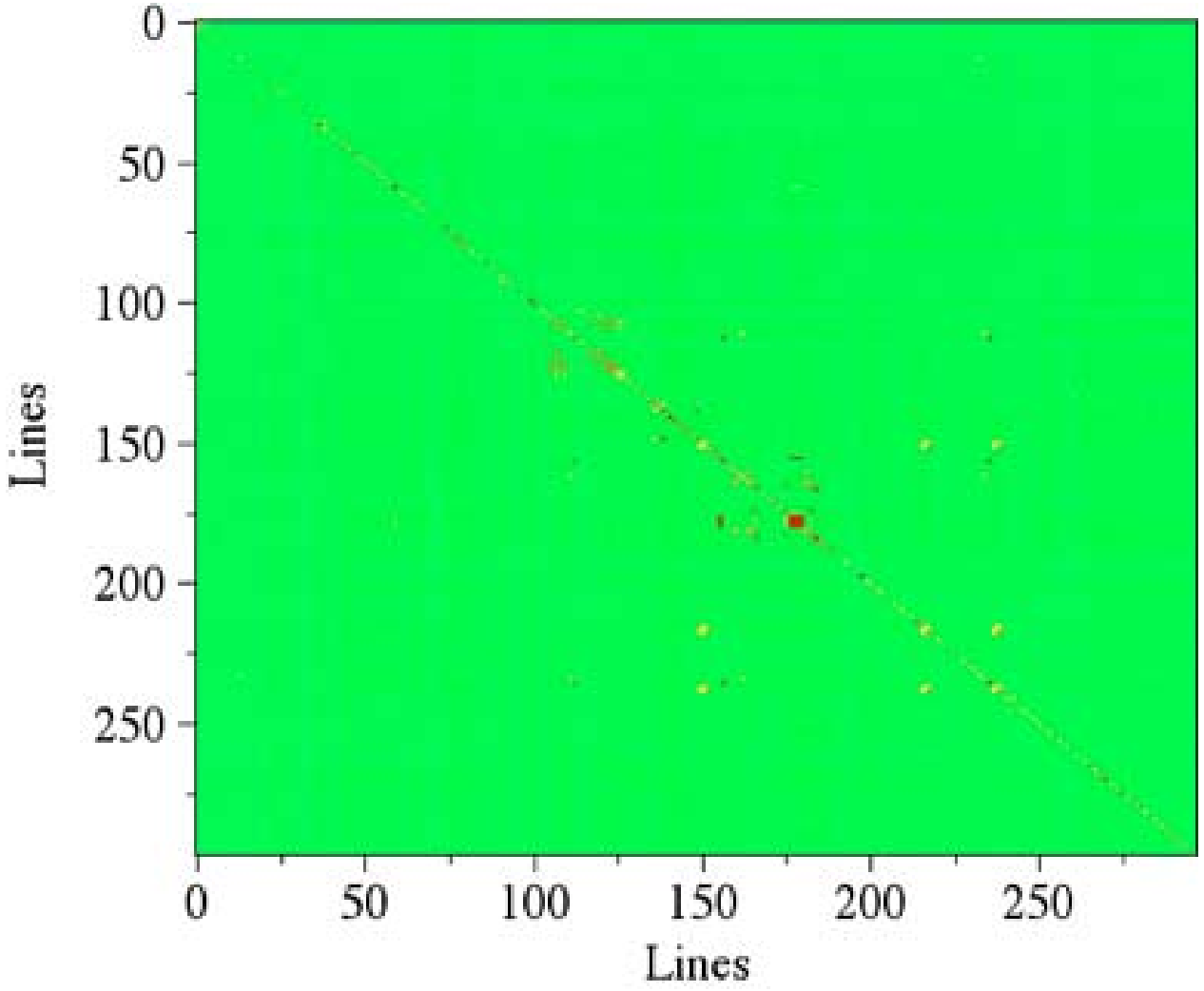
Blackout size

Critical corridors: which combinations of lines fail in many blackouts?



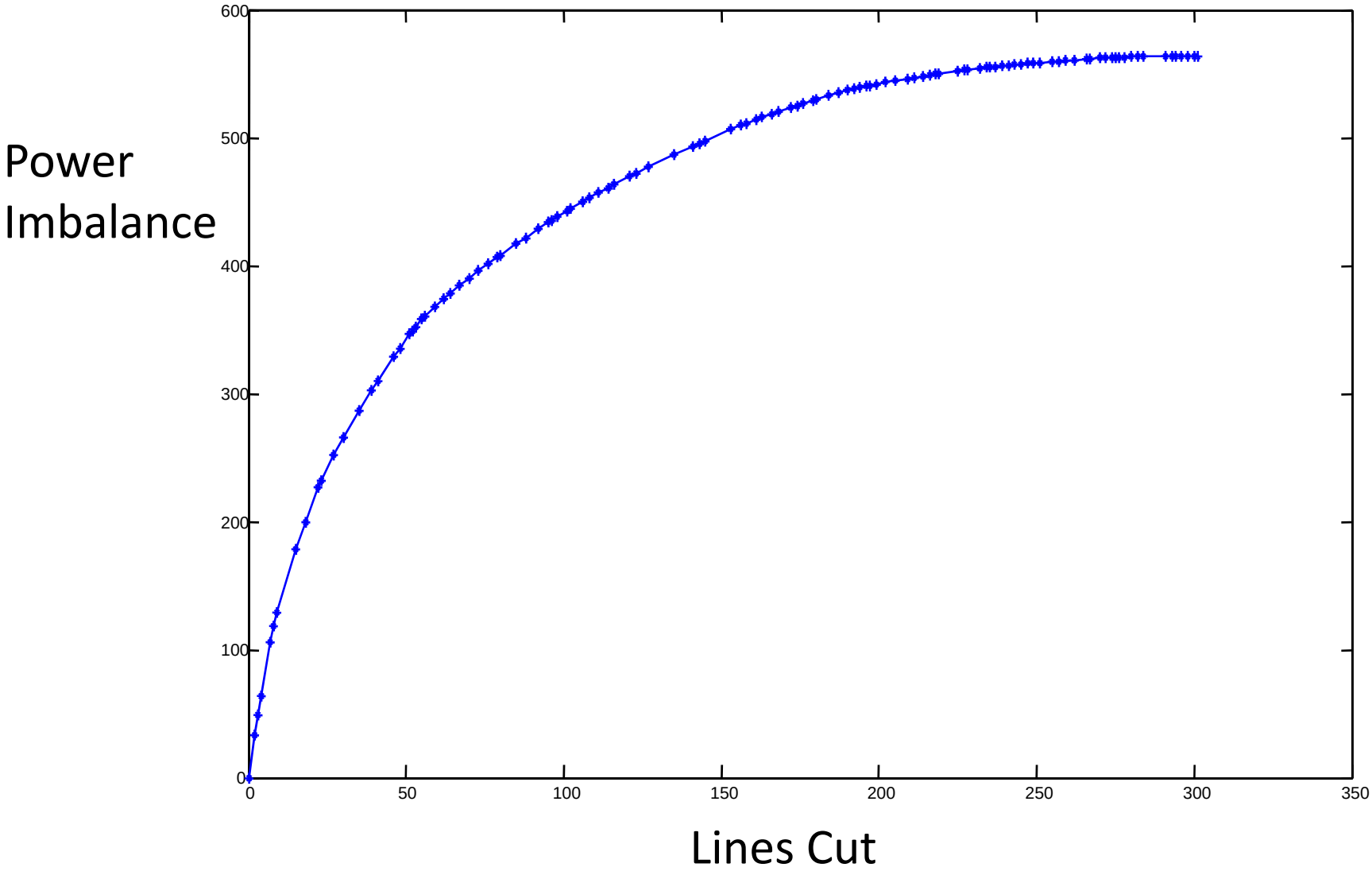
TRELSS processing

What clusters of lines tend to fail together in larger blackouts?

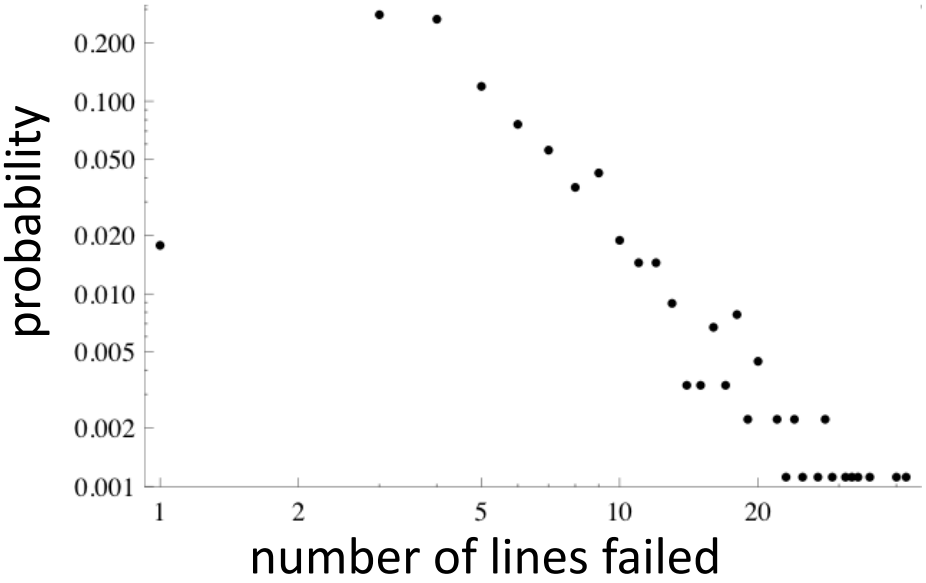


OPA on WECC 225

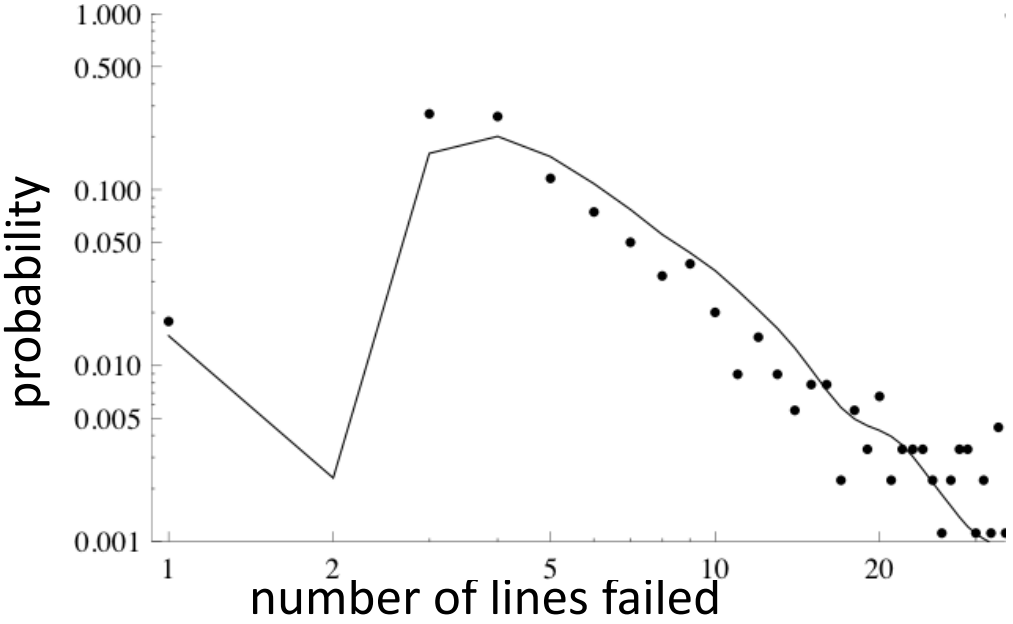
Vulnerability Frontier; WECC 1081 bus



Initial line failures



line failures after cascading



Does branching fit simulated cascades?

(1) Run TRELSS on industry case; get distribution of initial and final line failures (dots)

(2) Compute average propagation $\lambda=0.2$

(3) Use branching model with $\lambda=0.2$ and initial line failures to predict final line failures (line)

Some key goals/outcomes

- Quantify the risk of large blackouts
- Locate weak spots and quantify reliability improvements
- Compare and improve different modeling approximations and different approaches and better define what can be learned from them
- Define gaps in methods and understanding and the path forward.